Data Quality Objectives for Project 1A: Concentration and Effects of Selenium in Shorebirds

Step	DQO Guidance of Purpose and Outputs of Step	Great Salt Lake Project
1. Problem Statement	**Purpose:** Clearly define the problem that requires new environmental data so that the focus of the study will be clear and unambiguous. **Outputs From This Step** • A concise description of the problem. • A list of the planning team members and identification of the decision maker. • A summary of available resources and relevant deadlines for the study.	**Problem:** The Great Salt Lake (GSL) provides a critical resource for breeding shorebirds and consequently has been identified as a site of Hemispheric Importance. Shorebirds (American avocet, black-necked stilt) can be negatively affected by increased selenium contamination. High ambient levels of selenium may reduce reproductive success (Conceptual Model Component [CMC] 1). These species consume large quantities of macro-invertebrates and will likely assimilate selenium rapidly (CMC 11). In order to understand the potential effects of selenium on shorebirds at GSL the following questions need to be addressed: • What is the diet of American avocets and black-necked stilts at GSL? • What is the ambient concentration of selenium in the water and macro-invertebrates consumed by shorebirds? • What is the concentration of selenium within the liver and blood of American avocets and black-necked stilts? • What is the concentration of selenium within the eggs of American avocets and black-necked stilts? • What is the hatching success of American avocet and black-necked stilt eggs? **Planning team members:** Dr. John Cavitt (Principal Investigator), Gary Santolo (Project Advisor), with ultimate decision authority by Utah Department of Environmental Quality, considering input by the GSL Steering Committee and GSL Science Panel. **Resources:** Estimated budget for sampling year 2006 is $104,500, including lab costs. Field and laboratory equipment is available from Weber State University or through charter (e.g., airplanes and boats). Analytical laboratories will be used for chemical analysis of samples. Selenium-related expertise will be provided by CH2M Hill staff scientists. **Deadlines:** Technical memorandum addressing above questions will be completed by November 1, 2006.

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2. Decision Statements	**Purpose**: Define the decision(s) that will be resolved using data to address the problem. **Approach**: Identify the key question that the study attempts to address and alternative actions that may be taken, depending on the answer to the key study question. **Outputs From This Step** • A statement of the decision that must be resolved using data in order to address or solve the problem. • A list of possible actions or outcomes that would result from each resolution of the decision statement. *Note from EPA guidance on DQO: If the principal study question is not obvious and specific alternative actions cannot be identified, then the study may fall in the category of exploratory research, in which case this particular step of the DQO Process may not be needed.*	**Decisions:** The guiding questions for project 1a include the following • What do the shorebirds eat at GSL, and what are the transfer factors for selenium from the diet to bird eggs? • Are significant ecological effects occurring in American avocets and black-necked stilts? If so, to which ones and at which locations? • What are the associated selenium concentrations in tissues (including bird eggs)? **Possible outcomes:** • Information is adequate to quantify transfer factors for selenium from the diet to bird eggs and to conclude that current selenium loadings to GSL have a measurable adverse effect on American avocets and black-necked stilts. Steps should be taken to reduce present and future selenium loadings by establishing a more protective site-specific standard for selenium. • Information is adequate to quantify transfer factors for selenium from the diet to bird eggs and to conclude that current selenium loadings to GSL have no measurable adverse effect on American avocets and black-necked stilts in the open-water GSL ecosystem. Future selenium loadings to GSL can be maintained at this level or increased concurrent with low-intensity water-quality and biological monitoring. • Information is not adequate to quantify transfer factors for selenium from the diet to bird eggs or to determine whether current selenium loadings to GSL have a measurable adverse effect on American avocets and black-necked stilts in the open-water GSL ecosystem. Further studies are needed to make a defensible conclusion about the significance of effects.

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3. Inputs to the Decision	**Purpose**: The purpose of this step is to identify the informational inputs that will be required to resolve the decision, and to determine which inputs require environmental measurements. **Activities** • Identify the information that will be required to resolve the decision. • Determine the sources for each item of information identified. • Identify the information that is needed to establish the action level for the study. • Confirm that appropriate field sampling techniques and analytical methods exist to provide the necessary data. **Outputs From This Step** • A list of informational inputs (including sources and potential action levels) needed to resolve the decision. • The list of environmental variables or characteristics that will be measured.	**Informational inputs:** The following inputs will be collected at four sites within the GSL: • Diet of American avocets and black-necked stilts at GSL • Ambient concentration of selenium in the water and macro-invertebrates consumed by shorebirds • Concentration of selenium within the liver and blood of American avocets and black-necked stilts • Concentration of selenium within the eggs of American avocets and black-necked stilts • Hatching success of American avocet and black-necked stilt eggs **Variables/characteristics to be measured:** • Aggregate percentage and aggregate volume (cc) of food items recovered from the upper digestive tract (pharynx, esophagus, proventriculus, and ventriculus) of American avocets and black-necked stilts • Selenium concentration in the following: – Water near foraging sites – Macro-invertebrates samples at foraging sites – Liver and blood of avocets and stilts – Avocet and stilt eggs • Hatching success at each site monitored • Other variables: – Incidence of embryo mortality and abnormalities in nesting birds – Body condition of American avocet and black-necked stilts

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4. Study Boundaries	**Purpose**: Specify the spatial and temporal circumstances that are covered by the decision. **Activities** • Define the domain or geographic area within which all decisions must apply. • Specify the characteristics that define the population of interest. • When appropriate, divide the population into strata that have relatively homogeneous characteristics. • Define the scale of decision making. • Determine when to collect data. • Determine the time frame to which the study data apply. • Identify any practical constraints on data collection. **Outputs From This Step** • Characteristics that define the domain of the study. • A detailed description of the spatial and temporal boundaries of the decision. • A list of any practical constraints that may interfere with the study.	**Spatial:** The project area is defined as the open waters of the Great Salt Lake (also referred to as Gilbert Bay) located north and west of Farmington Bay, west of the Weber River input, and south of Promontory Point, Bear River Bay, and the North Arm (bounded by the railroad causeway). The following four study areas will be surveyed for nesting aggregations: • West Carrington Bay – This area has almost no freshwater input and may be influenced by the deep brine layer that forms and depletes at different times than the main body of the lake. • The South Shore and Eardley Spit – These areas have very little fresh water inflow. • The Southeast Corner of the GSL – This area experiences inflows from the Goggin Drain and Lee Creek, both of which are primarily freshwater. The C-6 ditch flows in from Kennecott and a pipeline of Kennecott wastewater is also discharged into the main body of the lake near this area. • Pintail flats at Ogden Bay – This area is influenced by freshwater from all of the main inflows to the lake. **Temporal:** The period of data collection will be from April to August 2006 (possibly extending to April to August 2007). Initial results will be obtained by November 2006. Annual variation may be determined by repeating data collection during the 2007 breeding season. It is assumed that the need for extending this task will be evaluated at the end of 2006. **Practical constraints on data collection:** Occurrence of breeding birds is a major constraint for this project. Study sites were chosen due to unique attributes of hydrology and may not contain breeding aggregations. Weather is also a constraint for this project, because storms can limit our ability to conduct the sampling and measurement activities on the lake. Availability of boats and other field equipment, as well as equipment functionality, also may limit some activities.

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5. Decision Rules	**Purpose**: The purpose of this step is to integrate the outputs from previous steps into a single statement that describes the logical basis for choosing among alternative actions. **Activities** • Specify the parameter that characterizes the population of interest. • Specify the action level for the study. • Combine the outputs of the previous DQO steps into an "if...then..." decision rule that defines the conditions that would cause the decision maker to choose among alternative actions. **Outputs From This Step** • An "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative courses of action.	• If information is adequate to quantify transfer factors for selenium from the diet to bird eggs and to conclude that current selenium loadings to GSL have a measurable adverse effect on American avocets or black-necked stilts in the open-water GSL ecosystem, then the Science Panel will assist the Utah DEQ and the Steering Committee in establishing a site-specific selenium standard to reduce selenium loading. • If information is adequate to quantify transfer factors for selenium from the diet to bird eggs and to conclude that current selenium loadings to GSL have no measurable adverse effect on avocets or stilts in the open-water GSL ecosystem, then the Science Panel will assist the Utah DEQ and the Steering Committee in establishing a site-specific selenium standard, presumably maintaining the current level or increasing it, concurrent with low-intensity water-quality and biological monitoring. • If information is not adequate for the Science Panel to quantify transfer factors for selenium from the diet to bird eggs or to determine whether current selenium loadings to GSL have a measurable adverse effect on avocets and stilts in the open-water GSL ecosystem, then further studies will be recommended to provide the needed information for the Science Panel.
6. Tolerable Limits on Decision Rules	**Purpose**: Specify the decision maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data. **Activities** • Determine the possible range of the parameter of interest. • Define both types of decision errors and identify the potential consequences of each. • Specify a range of possible parameter values where the consequences of decision errors are relatively minor (gray region). • Assign probability values to points above and below the action level that reflect the acceptable possibility for the occurrence of decision errors. • Check the limits on decision errors to ensure that they accurately reflect the decision maker's concern about the relative consequences for each type of decision error. **Outputs From This Step** • The decision maker's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision.	Because of the judgmental nature of the sampling approach used in this study, no acceptable limits for decision error rates were determined for the sampling design. Specifications of tolerable limits on decision errors through the use of standard statistical methods are not applicable for these parameters. Data quality may also be specified under Measurement Quality Objectives. This quality assessment typically involves specifying performance criteria in terms of the precision, accuracy, representativeness, completeness, and comparability of the data. These performance criteria provide a measure of how well the established Measurement Quality Objectives were met. For this investigation, Measurement Quality Objectives for chemical measurements will be specified in the Quality Assurance Project Plan (QAPP); in general, the Measurement Quality Objectives for selenium are about ±20% and for non-selenium measurements they are ±10%. The QAPP will specify all QA/QC objectives for sample measurement based on each matrix and may be more restrictive or less restrictive than ±20%.

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7. Optimization of the Sampling Design	**Purpose**: Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs. **Activities** • Review the DQO outputs and existing environmental data. • Translate the information from the DQOs into a statistical hypothesis. • Develop general sampling and analysis design alternatives. • For each design alternative, formulate the mathematical expressions needed to solve the design problems. • For each design alternative, select the optimal sample size that satisfies the DQOs. • Select the most resource-effective design that satisfies all of the DQOs. • Document the operational details and theoretical assumptions of the selected design in the Sampling and Analysis Plan. **Outputs From This Step** • The most resource-effective design for the study that is expected to achieve the DQOs, selected from a group of alternative designs generated during this step.	The sampling plan is summarized as follows: • Nesting areas will be surveyed by aerial transect beginning in late April and coordinates of nesting aggregations will be recorded to facilitate the remaining tasks. • Once nesting aggregations have been identified, they will be visited to determine the stage of breeding and to identify foraging locations. • Five adults of each species will be collected at each site at the beginning of the nesting season, after observing them feed for >15 minutes. Dietary information will be obtained by direct examination of gut contents (pharynx, esophagus, proventriculus and ventriculus). Blood (if possible) and liver samples will be taken from each bird for selenium analysis. • From each of the foraging areas, the following samples will be collected for selenium analysis: invertebrates (brine fly adults and/or larvae or pupae and brine shrimp, depending on what the birds are eating), surficial sediment, and water. If available, three samples of each species and life stage (i.e., larvae, pupae or adult of brine flies) will be collected at each area, with sufficient biomass for analysis (target 5 grams) and additional biomass when that is feasible. • A single egg will be collected from each of 10 nests for each species at each location upon discovery of the nest. After the clutches are completed, an additional 10 eggs containing late-stage embryos (based on egg flotation) per species will be collected from each site. Each embryo will be checked for stage of development and developmental abnormalities, including a determination of the embryo's position in the egg. Egg contents will then be placed in a marked chemically-cleaned container and preserved frozen for later analysis. Up to 10 eggs of each species from each site will be analyzed for total selenium; eggs with late-stage embryos will be selected preferentially, if available. The remaining samples will be stored for possible later analysis. • Nests of both species will be located within each site and monitored to provide data on breeding productivity such as hatching success and nesting success using established methods (such as Mayfield methods). Near the time of hatching, nests will be checked to collect any fail-to-hatch eggs.